SEISMIC PERFORMANCE FOR CABLE STAYED BRIDGE UNDER DIFFERENT EARTHQUAKE LOADINGS

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I/We* hereby declare that I/We* have checked this thesis/project* and in my/our* opinion, this thesis/project* is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at University Malaysia Pahang or any other institutions.

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ABSTRAK

Penyelidikan ini adalah berkaitan dengan analisis seismik struktur jambatan kabel yang berada di Malaysia dengan tujuan untuk mengira maklum balas dan menilai kapasiti rintangan struktur yang dipengaruhi oleh kekuatan gempa yang berbeza. Walau bagaimanapun, keadaan sempadan struktur jambatan dianggap sebaga tetap dan factor berkaitan tanah tidak timasukkan. Kajian ini dijalankan kerana gegaran di Malaysia adalah disebabkan oleh gelombang seismik yang dijana daripada gempa bumi yang berlaku di negara-negara jiran. Oleh itu, jurutera-jurutera bimbang tentang kelemahan seismik struktur jambatan kerana kekurangan pertimbangan gempa dalam prosedur reka bentuk bangunan Malaysia. Struktur jembatan adalah struktur kritis yang akan musnah d akibat gelombang seismik dan juga komponen penting dalam sistem pengangkutan. Dengan ini, jambatan kabel kekal dimodelkan dan dianalisis dengan menggunakan perisian *Finite Element Modeling* (FEM) oleh perisian SAP2000 di bawah pelbagai jenis analisis yang meliputi Analisis Getaran Bebas (FVA) dan Analisis Sejarah Masa (THA) di bawah pemuatan gempa yang berbeza. Beban angin auto dalam SAP2000 telah digunakan dalam kedua-dua analisis. Data kekuatan gempa diambil daripada gempa Acheh dan El-Centro yang telah direkodkan oleh Jabatan Meteorologi Malaysia. Kegunaan dua jenis kekuatan gempa yang berbeza akan menghasilkan nilai ciri-ciri pergerakkan struktur jambatan yang berbeza. Selain itu, prestasi seismik keseluruhan jambatan kabel kekal ketara dipertingkatkan dalam arah membujur dan melintang. Ia boleh meringkaskan bahawa reka bentuk jambatan kabel dan keupayaan untuk bertahan gelombang seismik besar dan kecil serta juga boleh menghasilkan daya tahan yang mencukupi terhadap pemuatan gempa yang berbeza.

ABSTRACT

The paper deals with the seismic analysis of a stayed cable bridge structure in Malaysia with the aim to compute the response and assess the resistance capacity of the structure under different earthquake loading. Nevertheless, the border state of the stayed cable is assumed as fixed to the ground and type of soil has been neglected. The study was conducted because the tremors in Malaysia were due to the seismic wave generated from the earthquake that occurred in neighbouring countries. Therefore, engineers are concerned about the seismic vulnerability of bridge structures due to lack of earthquake consideration in Malaysia's building design procedure. Bridge structure is the critical structure that will damage cause by the seismic effect and also important component in transportation system. With this, stayed cable bridge is modelled and analysed using Finite Element Modelling(FEM) by SAP2000 software under various type of analysis that cover Free Vibration Analysis (FVA) and Time History Analysis (THA) under the different earthquake loading. Auto wind load in SAP2000 has been used in both analyses. The earthquake loading data is taking from Acheh and El-Centro earthquake that had been record by Malaysia Meteorological Department. Implementation between two type of different earthquake loading will represent the contrasting of dynamic characteristic of bridge structure. Furthermore, the overall seismic performance of stayed cable bridge significantly enhanced in longitudinal and transverse directions. It can summarize that the design of the stayed cable bridge is stable and ability to withstand under major and minor earthquake and also can yield adequate resistance against different earthquake loading.

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LIST OF SYMBOLS

km	kilometer
cm/yr	centimetre per year
m/s^2	metre per square second
Hz	Hertz
M	Meter
Nm	Newton meter
Mm	Milimetre
N	Newton
m/s	Meter per second
m^2	Meter square
g	Gal
s	second

LIST OF ABBREVIATIONS

3D	Three dimensional
DL	Dead load
LD	Live load
RSA	Response Spectrum Analysis
SAP	Structural Analysis & Design Program
WL	Wind load
EC	Euro code
P	Primary
S	Secondary
L	Love
R	Rayleigh

CHAPTER 1

INTRODUCTION

1.1 Background of study

Earthquake is natural disaster that happens in an instant without any early signs. It usually occurs when rock underground suddenly breaks along a fault. This sudden produce of energy and causes the seismic wave that make the ground shaking. Seismic waves are created from the energy released from the earthquake. Structure buildings may be affected and suffered great damage due to the seismic waves. The structures building may defect in term of deflection and cracking that may reduce the aesthetic value of the building. For example, an earthquake with a magnitude of 9.3 occurred on December 26th, 2004, outside the beach of the Indonesian island of Sumatra, at 7.59 a.m. local time. Wide seismic breakdown to engineering infrastructure and construction development happened in northern and north-western Sumatra. A destroyer tsunami was produced with height of power wave exceeding 20 m, involve extensive ruination in Malaysia, Indonesia, Thailand, Burma , Sri Lanka , and other countries around the Indian Ocean.

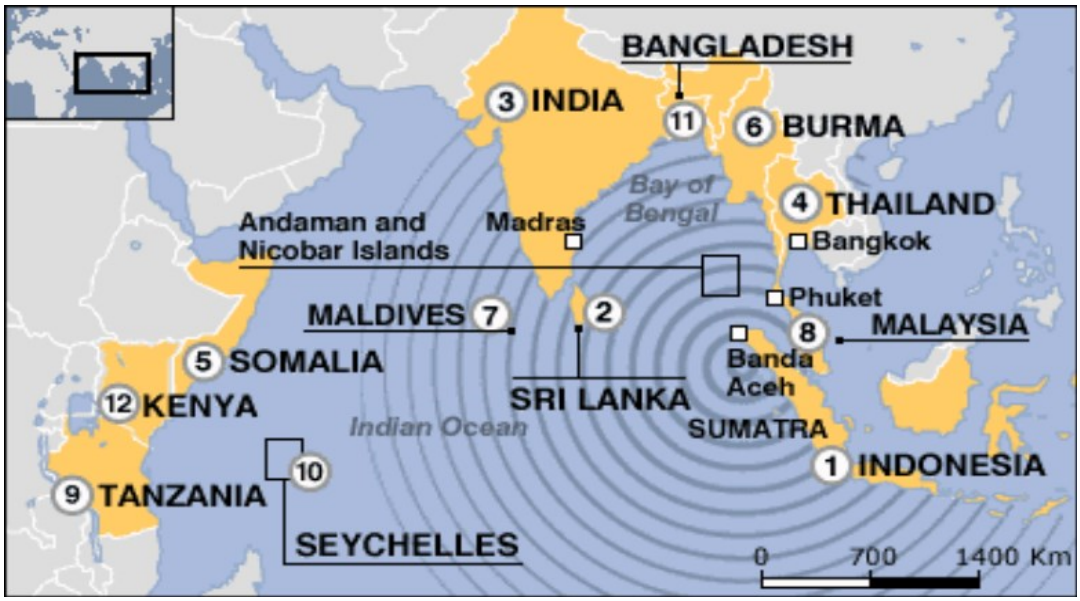

Figure 1.1 Countries in the Indian Ocean affected by the 26 December 2004 tsunami (source: BBC)

The occurred of tsunami were sensed as far away along the east coast of Africa. The total fatalities more than 300,000. Many of people were impressed, many people missing their house, property and suffering very sad.

Cable-stayed bridges have emerged as the dominant structural system for long span bridge crossings during the past thirty years. That success is due to a combination of technical advancements and pleasing aesthetics attributes. Cable-stayed bridges can be categorizing as a justifiable solution for connecting wide-span crossings. There are more than 600 cable stayed bridge were constructed until now. Usually, the span of cable bridges is between 100m to 500m wide while the length of widest cable bridges has increased up to 1000m during this decade. Cable-stayed bridges are studied from many aspects such as number of spans, number of towers, number of cables and girder types. This type of bridges must take into all aspects design including the earthquakes loading because earthquakes occur without any initial warning. Bridge failure during strong earthquakes poses not only a threat of fatalities but causes a substantial interruption of emergency efforts. The bridge failure is actually influence by combination of poor design and inclement weather condition. Although wind induced vibrations have historically

been the primary concern in the design of cable-stayed bridges, earthquake effects have also gained importance in recent decades.

1.2 Problem statement

The tectonic framework for the whole of Malaysia covers between longitudes 90 E to 140 E and latitudes of 12 S to 20 N (MMD and ASM, 2009). Malaysia is viewed to have lower active seismic fault zone and it is detected on the Eurasian plate, and closer to the two interpolate border which are the Philippines Plate in the east and Australian Plates in the west. Nowadays, there are many evidences obviously proving that initial presumption Malaysia are save from earthquake is misleading to Malaysian people. It is importance value to state that one of the phenomena from regional earthquake that bring bad high impacts Malaysian is the Indian Ocean earthquake on 2004 with the magnitude of 9.1. The strong earthquake that provide occur tsunami contingencies, terrible and frighten has killed nearly 68 lives in Malaysia and thousands of other lives in Indonesia, Sri Lanka and Thailand.

Most building structures in Malaysia are not included the earthquake load. This is because some people in Malaysia believe that the country is free from the threat of active seismic zone. But if seen through the history that has taken place, Malaysia has ever been affected by the long-term impact of the earthquake that took place in the Indian Ocean (Eurasian plate). Hence, all building structures in Malaysia need to be designed with earthquake loads to increase the safety factor of a building. The cable-stayed bridge structure in Malaysia is tabled and selected to be investigated whether the construction involves an earthquake load or not. Therefore, this research study will demonstrate the responsible earthquake to cable-stayed bridge in Malaysia region. SAP2000 was used to analyse and modelling the structure of cable-stayed bridge.

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